Pacific Northwest NATIONAL LABORATORY

GRID OPTIMIZATION (GO) COMPETITION

arpa·e SM

Grid Optimization Competition Challenge 2

ARPA-E Outreach Event

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U.S. DEPARTMENT OF ENERGY BATTELLE

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PNNL is operated by Battelle for the U.S. Department of Energy

AIMMS

AMPL

GAMS

GUROBI OPTIMIZATION

NREL NATIONAL RENEWABLE ENERGY LABORATORY

TAMU

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mosek

SIEMENS Ingenuity for life

WISCONSIN UNIVERSITY OF WISCONSIN–MADISON

ASU ARIZONA STATE UNIVERSITY

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Georgia Tech

Engagement

- Individuals must register https://gocompetition.energy.gov/user/register
  - Active participants: 93 (logged in since July 21, 2020 Challenge 2 announcement)
- Individual(s) form teams:
  - Create Team: https://gocompetition.energy.gov/howto-create-team
    - ✓ Only the leader can create or change a team (anonymous teams ok with restrictions)
    - ✓ Requires GitHub account
    - ✓ Allows use of Sandbox submissions
  - Register team: https://gocompetition.energy.gov/howto-register
    - ✓ Required for Event submissions
    - ✓ Team sizes ranged from 1 to 7 members
  - C2 Teams created: 26 (51 teams created under Challenge 1; 38 approved)
  - C2 Teams approved: 21; participated in 1 or more Events: 16
  - C2 Teams participating in Final Event: 15 (+Benchmark)

Participation

- Sandbox Submissions https://gocompetition.energy.gov/challenges/sandbox
  - Run single scenarios on PNNL Platform from website
    - ✓ Specify dataset, model, scenario, runtime parameters
    - ✓ Receive run status and results URL
  - Event datasets available after Event closes
- Event Submissions https://gocompetition.energy.gov/challenges/challenge-2
  - Single submission before Event deadline
    - ✓ All scenarios and Divisions run using code specified at time of submission
    - ✓ Initial results provided via e-mail
    - ✓ Rerun requests during certification period https://gocompetition.energy.gov/competitor-final-results-certification-period
    - ✓ Results announced on Leaderboard https://gocompetition.energy.gov/challenges/challenge-2/Leaderboards
- Challenge 2 received 9,914 Sandbox and Event submissions from 16 teams

The Problem

- Builds on Challenge 1 SCOPF problems
  - Single period ACOPF with security constraints
  - Short term operational actions – 5 to 15 minutes prior to real time
  - Use in planning – pre-determine actions that can be deployed in real time
- Includes new features to allow further optimization
  - Generators
    - ✓ Ramp rate constraints
    - ✓ Unit commitment of fast-start generators
  - Bid-in demand
  - Topology optimization
    - ✓ Line-switching
    - ✓ Phase shifting transformers
    - ✓ Variable transformer taps
    - ✓ Switchable shunts

Carleton will provide further details

Problem Formulation: https://gocompetition.energy.gov/sites/default/files/Challenge2_Problem_Formulation_20210531.pdf
Primary author: Jesse Holzer, 97 pages, 299 equations

The Data

- 3 ASCII encoded text files for each problem instance used as input
  - Power Flow Network Configuration Data File (case.raw)
  - Contingency Description Data File (case.con)
  - Supplementary Data File (case.json) (**J**ava**S**cript **O**bject **N**otation is an XML alternative)
- ASCII encoded text files used as output; 1 for base and each contingency
- All solution files have the same same format; a **fixed sequence** of six sections, each delimited by a start line with two hyphen characters in columns 1 and 2 followed by a table of comma separated values with a header row and a series of data rows.
  - Bus section
  - Load section
  - Generator section
  - Line section
  - Transformer section
  - Switched shunt section

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Data Validation

- Providers send data to PNNL
- PNNL runs
  - Validation check
  - “Scrubber” to remove inconsistencies and manageable errors
  - Rerun validation check on “scrubbed” data
  - Reports problems back to providers
- Verify existence of feasible solution (PNNL & LANL)
- Assess ”difficulty” (LANL)
- Respond to reports from Entrants
- Update validation code, repeat cycle
- Down select a set with a range of features for Event.

Evaluation

- The code from all teams is run on the same hardware platform at PNNL. Teams could use up to 144 cores across 6 nodes.
- 11,964 scenarios evaluated for Final Event
- The Evaluation computes the Market Surplus objective from the solution data

Summary of Evaluation Algorithm:

https://gocompetition.energy.gov/challenges/challenge-2/solution-evaluation

Evaluation Algorithm available:
https://github.com/GOCompetition/C2DataUtilities

Scoring

- The solution to scenario s is evaluated and assigned MS^{total}_s
- MS^{total}_s set to MS^{pp}_s if
  - No solutions files were created (C1 or C2 timed out or aborted)
  - Solution files were incorrectly formatted
  - The solution is determined to be infeasible
  - $MS^{total}_s < MS^{pp}_s$
- Gain in market surplus relative to the prior point set to $MS^{gain}_s = MS^{total}_s - MS^{pp}_s$
- The score over a given set S of scenarios is $MS^{gain} = \sum_{i \in S} MS^{gain}_s$
- MS^{gain} determines a team's rank for each division
- The top 5 eligible teams in each division receive prizes
  - The ARPA-E Benckmark team is not prize eligible.

Download the Scoring document

Timeline

- Trial Event 1 https://gocompetition.energy.gov/challenges/challenge-2/Leaderboards/Trial1
  - December 1, 2020, registration approval closed
  - December 2-4, 2020, submission interval (12 received)
  - January 8, 2021, Trial 1 results announced and synthetic scenarios (63) released. Industry scenarios (20) not
- Trial Event 2 https://gocompetition.energy.gov/challenges/challenge-2/Leaderboards/Trial2
  - May 1, 2021, registration approval closed
  - May 2-4, 2021, submission interval (13 received)
  - May 21, 2021, Trial 2 results announced and synthetic scenarios (54) released. Industry scenarios (14) not
- Trial Event 3 https://gocompetition.energy.gov/challenges/challenge-2/Leaderboards/Trial3
  - June 27, registration approval closed
  - June 28-30, 2021, submission interval (14 received)
  - July 16, 2021, Trial 3 results announced and synthetic scenarios (54) released. Industry scenarios (12) not
- Final Event https://gocompetition.energy.gov/challenges/challenge-2/Leaderboards/Final
  - July 12, registration approval closed
  - August 9-11, 2021, submission interval (15 received)
  - October 5, 2021, Final Event results announced. Synthetic scenarios (84) released 9/17 with initial team results. Industry scenarios (36) not released

Challenge 2: Sponsors & Support

- Sponsors (software providers)
  - AIMMS
  - AMPL
  - GAMS
  - Gurobi Optimization
  - IBM (CPLEX)
  - MOSEK
  - Siemens
- Technical Support
  - Arizona State University
  - Georgia Institute of Technology
  - Los Alamos National Laboratory
  - Pacific Northwest National Laboratory
  - Texas A&M University
  - University of Wisconsin – Madison

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Thanks for listening

https://gocompetition.energy.gov/